Note

Properties of Particleboard from Lesser-used Species I. *Albizia falcata* Backer*

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Abstract——Flakeboards in the density range of 0.4–0.65 g/cm^3 were produced using *Albizia falcata* as raw material and a urea formaldehyde resin, a phenol-melamine formaldehyde resin, and an isocyanate compound as adhesives. Mechanical properties and dimensional stability of boards were determined.

Using long flakes from this low-density species, high *MOE* and *MOR* was obtained in relatively low-density board. Further improvements in internal bond strength and the dimensional stability in thickness direction may enable to produce boards sufficient for structural use. Isocyanate bonded board showed superior properties to those bonded with other adhesives.

1. Introduction

Utilization of lesser-used tropical hardwood species, for particleboard is considered to be one of promissing means of expanding the raw material base for the wood industry. Technically, it is possible to make particleboards from many species of wood in almost any form, regardless of board qualities. However, only limited number of species are being used, and information on many unused species of hardwood is lacking[1,2]. *Albizia falcata* and other fast growing tree species, for instance, still haven't found any major use as structural building materials. In this paper the suitability of *Albizia falcata*, one of unused species in Indonesia, as a raw material for particleboard bonded with urea formaldehyde, phenol-melamine formaldehyde, and isocyanate adhesive resin will be discussed.

2. Experimental

Raw material used was Moluccan sau (*Albizia falcata* Backer) with an air-dry density of 0.34 g/cm^3. Fingerings were prepared using a circular saw with nominal size 50 (fiber direction) $\times 25 \times 20$ mm, and they were prepared to flake-type par-

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ticles with a Pallmann knife-ring flaker. The average dimensions of the particles were 30 mm in length, 2.0 mm in width and 0.48 mm in thickness. A part of the particles were dried with a vacuum dryer until about 5 percent moisture content and the rest were conditioned to 10 percent moisture content.

In addition to a conventional urea formaldehyde resin (UF), U-Loid 555 formulated by Mitsui Toatsu Kagaku Co. Ltd., new types of resin for particleboard were used; an isocyanate compound adhesive (IC), UL-4800 formulated by Gun-ei Kagaku Kogyo Co. Ltd., and a phenol-melamine formaldehyde resin (PMF), U-Loid NV 101 formulated by Mitsui Toatsu Kagaku Co. Ltd. Resin content level of boards for all types glue was 8 percent resin solids based on oven-dry weight of particles. In the isocyanate adhesive formulation, acetone was added at 20 percent based on weight of resin solid, while water was added to phenol-melamine formaldehyde and urea formaldehyde adhesives to attain 50 percent resin concentration, and get a suitable viscosity for spraying. The resin was sprayed on the particles in a drum-type rotary blender by means of an airless gun. Particles with 5 percent moisture content were used for PMF and UF resins, while those with 10 percent moisture content for IC, which were established to be the optimum moisture content for bonding strength in each resin in the previous experiment[3]. Hand-formed particle mats were pressed at 160°C for isocyanate resin and 130°C for phenol-melamine formaldehyde and urea formaldehyde resins. For IC resin, both top and bottom surfaces of the mat was covered with glass-fiber reinforced Teflon sheets so as to prevent the mat from sticking to the platens. Target board densities were 0.4, 0.5 and 0.65 g/cm^3 in air-dry condition. The initial pressures of 15, 20, and 25 kg/cm^2 were applied for 30 seconds for the boards with densities of 0.4, 0.5, 0.65 g/cm^3[3], respectively. The total pressing time was 7 minute for UF and PMF resins, and 3.5 minute for IC resin, applying a step-down method of pressing.

Specimens cut out of boards with the dimensions of $400 \times 350 \times 12$ mm were tested after conditioning for 2 weeks at 20°C and 65% RH. Modulus of elasticity (MOE) and modulus of rupture (MOR) both in air-dry and wet conditions, internal bond strength (IB) and screw-withdrawal resistance (SW) in air-dry condition, and thickness swelling (TS) after 24-hours water immersion were measured according to JIS A-5908. In addition, linear expansion (LE) was measured with the wet-bending test specimens. The wet treatment for bending test was two hours boiling, then one hour water immersion at room temperature for PMF and IC bonded boards, and two hours immersion at 70°C, then one hour water immersion at room temperature for UF bonded board. Six replications were used for each condition.

3. Results and Discussion

The relationships between *MOE, MOR* in air-dry condition and the board density are shown in Fig. 1 and Fig. 2, respectively. Both *MOE* and *MOR* of boards bonded with each type of resin increased linearly with an increase of board density. IC and PMF bonded boards showed higher *MOE* than UF board at the same board density with the IC boards showing the highest *MOR* values. Type 200

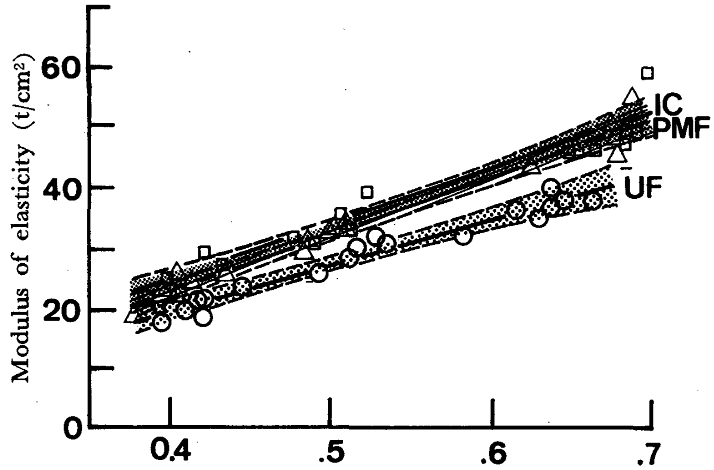

Fig. 1. Modulus of elasticity in dry condition as a function of board density. Legend: IC; Isocyanate bonded board, PMF; Phenol-melamine formaldehyde bonded board, UF; Urea formaldehyde bonded board.

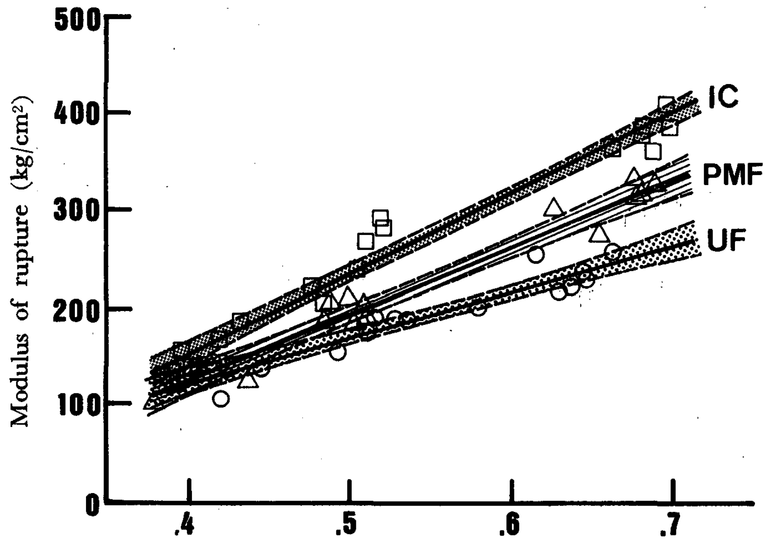

Fig. 2. Modulus of rupture in dry condition as a function of board density. Note: Legend is the same as in Fig. 1.

particleboard graded by JIS can be obtained with IC, PMF and UF bonded boards at an air-dry density of 0.45, 0.50, and 0.55 g/cm[3]), respectively. Similar observation were reported in a previous paper[3]), but the values obtained in this experiment were somewhat lower than those in the previous experiment at the same board density level. This is perhaps due to different methods of particle preparation. Visual observation indicated that the ring-flaker used in this experiment produced more

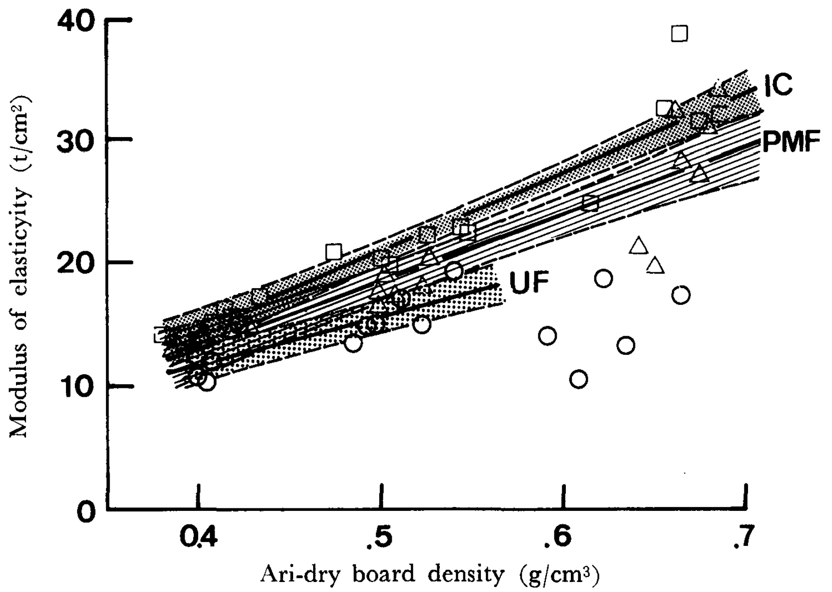

Fig. 3. Modulus of elasticity in wet condition as a function of board density. Note: Legend is the same as in Fig. 1.

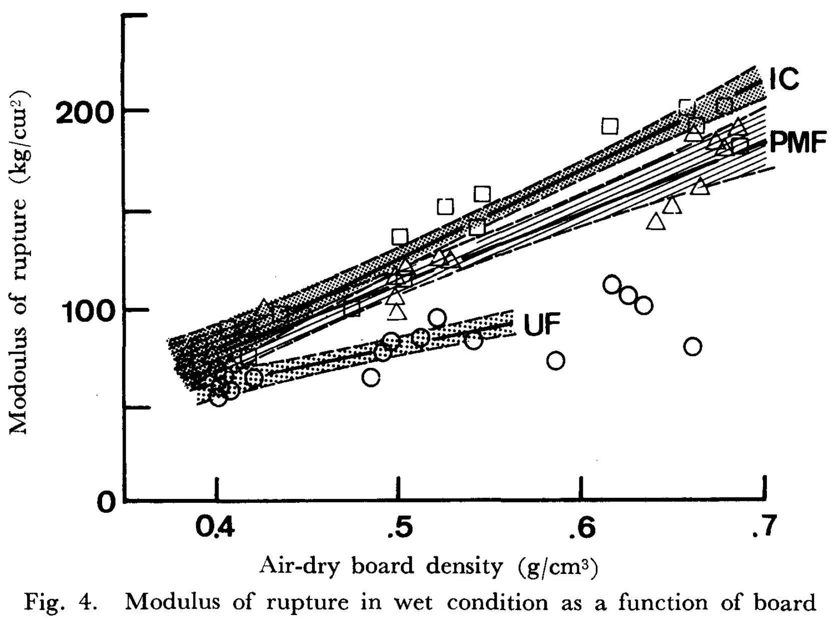

Fig. 4. Modulus of rupture in wet condition as a function of board density. Note: Legend is the same as in Fig. 1.

damage to particles than drum-flaker used in the previous experiment.

Figures 3 and 4 show the relations of *MOE* and *MOR* in wet condition to the board density, respectively. The wet *MOE* and *MOR* showed trends similar to the dry *MOE* and *MOR*, respectively. However, delamination was observed after the treatment in the UF bonded board of higher density. These values were subsequently excluded from the regression equation. The retentions of the *MOR* of IC, PMF and UF bonded board were 53%, 58%, and 47%, respectively.

The *IB* of particleboard is a measure of bonding efficiency. Internal bond

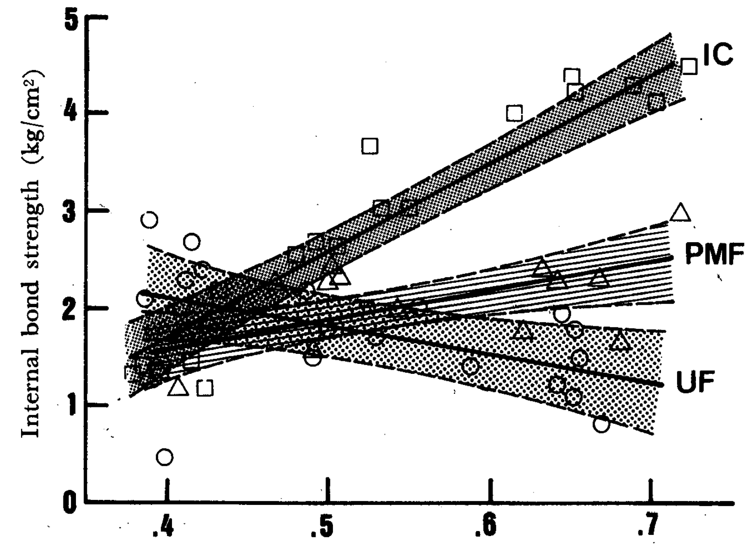

Fig. 5. Internal bond strength in relation to the board density.
Note: Legend is the same as in Fig. 1.

of IC and PMF bonded board increased with increasing board density, as shown in Fig. 5. On the other hand, *IB* of UF bonded board decreased with increasing board density. This peculiar trend may be due to the local delamination of UF boards of higher density; The bonding strength of UF resin could not exceed the internal stress of board due to excess moisture which could not escape from the mat because of the high compaction ratio with thin flakes. This can be observed in the springback phenomenon after conditioning, as shown in Fig. 6. Thickness of UF bonded particleboards increased after conditioning. The internal bond strength of IC and PMF bonded boards is only one-half of that of lauan board of the same density[3]. This can be partly explained by the difference in method of particle preparation, as previously discussed. The low density of raw material also made it more difficult to obtain higher quality particles. The bond-ability of the wood species may be another reason. Further experiments to improve board *IB* of board with special consideration in particles preparation is necessary.

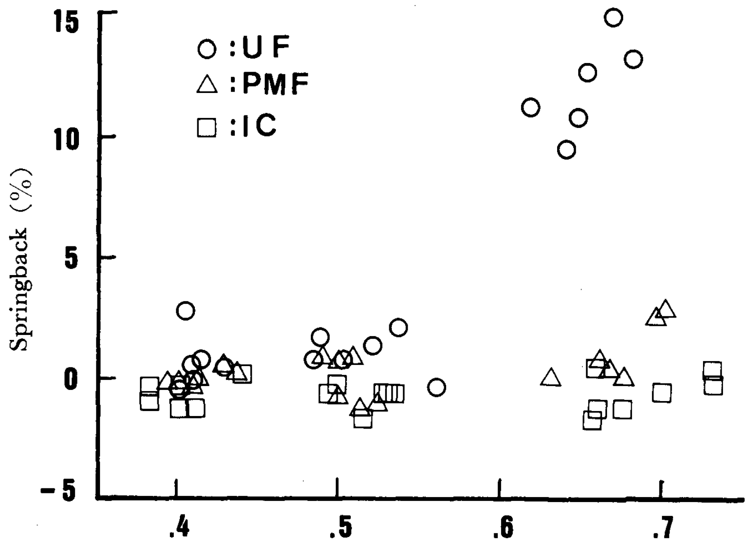

Fig. 6. Springback of particleboard after conditioning about 2 weeks. Note: "Springback" is defined here as the ratio of board thickness after conditioning to the target thickness.

$$\text{Springback } (\%) = \frac{D_1 - D_0}{D_0} \times 100$$

where; D_0: target thickness, D_1: thickness after conditioning. Legend is the same as in Fig. 1.

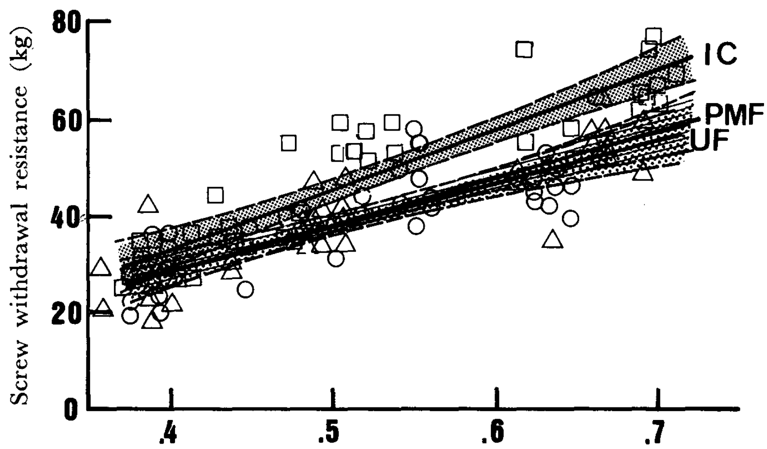

Fig. 7. Srew-withdrawal resistance as a function of board density. Nose: Legend is the same as in Fig. 1.

The relationships between srew-withdrawal resistance and board density is shown in Fig. 7. *SW* increased linearly with an increase of board density. *SW* seems to be influenced mainly by the density, although IC bonded board showed higher values than the other boards.

Fig. 8 shows the thickness swelling after 24 hours of water immersion in rela-

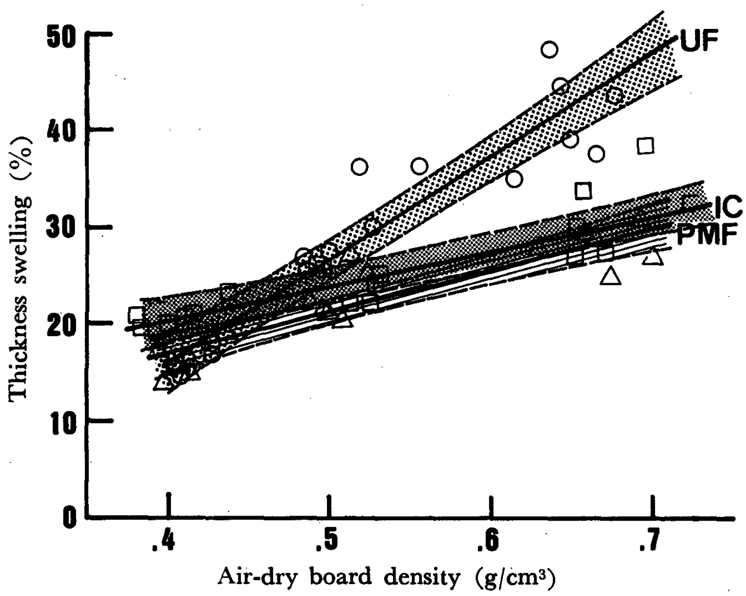

Fig. 8. Thickness swelling after 24 hours water immersion in relation to the board density. Note: Legend is the same as in Fig. 1.

tion to the board density. *TS* increased linearly with increasing board density, which may be due to greater thickness recovery after compression in higher density board. Compared with the other boards, UF bonded board had the greatest amount of thickness swelling.

Principally, *TS* would decrease with increasing the resin content and with decreasing compaction ratio, particle thickness, and particle length[4]. The quality

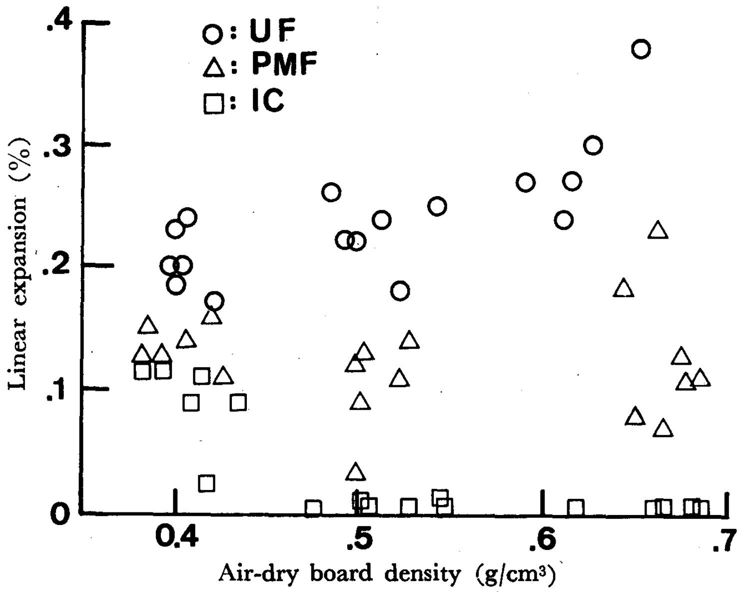

Fig. 9. Linear expansion in relation to the board density. Note: Legend is the same as in Fig. 1.

(i.e. particle surface condition, fiber damage) of the particles is may be another factor. Further experiments searching for suitable conditions to decrease the *TS* is necessary.

Fig. 9 shows the relation of linear expansion to the board density. The *LE* of IC-bonded boards showed the lowest values and decreased with an increase of board density, as is observed in other literature[5]. On the other hand, the *LE* of PMF bonded board seems to be independent of board density. The *LE* of UF bonded board increased with an increase of board density, and showed the highest value in spite of comparatively milder wet treatment.

4. Conclusions

Mechanical and dimensional properties of *Albizia falcata* flakeboard bonded with UF, PMF, and IC adhesives were determined. Using long flakes from low density species, high *MOE* and *MOR* was obtained in relatively low density board, but the internal bond strength and dimensional stability in thickness direction of boards were not sufficient. Further experiments searching for suitable conditions to decrease *TS* and improve *IB* is necessary. IC bonded board showed superior properties to those bonded with UF and PMF.

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